New Sources of Resistance to Greenbug in Barley

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ABSTRACT

Most biotypes of the greenbug [*Schizaphis graminum* (Rondani)] are extremely damaging to barley (*Hordeum vulgare* L.). However, greenbug biotype G has been reported to be unable to successfully feed on barley, and is described as the first greenbug avirulent to 'Wintermalt' barley (which is susceptible to all other greenbug biotypes). The objective of this study was to determine the pest status of greenbug biotype G in barley by characterizing the response of select barley cultivars and germplasm to greenbug biotype G feeding. Eight barley and four wheat (*Triticum aestivum* L.) cultivars and germplasm were challenged with biotype G and damage ratings recorded after 22 d of infestation. Barley is indeed a host of biotype G and genetic diversity exists within barley for reaction to attack by greenbug biotype G. Three barley cultivars were killed by biotype G, while five were resistant to feeding damage. These new sources of resistance to greenbug biotype G in barley should prove useful in the development of new greenbug-resistant barley cultivars.

The greenbug is an economically important pest of barley in the USA (Starks and Webster, 1985). A 1942 greenbug outbreak that caused an estimated $38 million yield loss in small grain production precipitated interest in the development of resistant cultivars in the USA (Atkins and Dahms, 1945). Early work in barley identified a single gene source of resistance to greenbug in PI 87181 (Gardenhire and Chada, 1961). This single dominant gene, *Grb*, was located on linkage group 1 and on the centromere-bearing segment of chromosome 1 in the T1-6a translocation of 'Will' barley (Gardenhire et al., 1973). Will barley was used as a parent to develop 'Post', which has been used extensively as a resistant check in greenbug studies (Puterka et al., 1988). A second source of resistance to greenbug was discovered in PI 426756 (Webster and Starks, 1984) that is also controlled by a single dominant gene (Merkle et al., 1987). Genetic studies showed that this new source of resistance was nonallelic to *Grb*, thus the gene symbol *Rsg2b* was assigned to this gene, and *Grb* was modified to *Rsg1a* (Merkle et al., 1987).

These two resistance genes provide protection against a variety of greenbug biotypes (C, E, F, G, and H) (Webster and Starks, 1984; Puterka et al., 1988) and have been the only sources of resistance reported to date. However, Puterka et al. (1988) reported that Wintermalt, a barley cultivar previously reported susceptible to all greenbug biotypes, was not damaged by the newly detected biotype G. Biotype G was described as the first greenbug isolate avirulent to Wintermalt. Subsequent work by Ogecha et al. (1992) confirmed that biotype G was less successful in feeding on Wintermalt compared with other biotypes. When compared with biotypes E and H, biotype G spent significantly less time salivating and less time feeding within the phloem, took significantly longer to begin reproduction, and produced fewer progeny on Wintermalt (Ogecha et al., 1992).

Biotype G is found throughout the Southern Great Plains of the USA (Anstead et al., 2003), where the potential for tapping the alternate use market for barley (e.g., bio-based fuels) has generated renewed interest in winter barley production. Despite its wide distribution, there exists a perception that biotype G is not a pest of barley; given its reported avirulence to Wintermalt, the susceptible barley check (Puterka et al., 1988). Little is known of its ability to damage barley or the level of genetic diversity within barley for resistance or susceptibility. On the basis of the inability of biotype G to feed successfully on both resistant and susceptible barley, we hypothesized that (i) barley is not an acceptable host, and therefore greenbug biotype G is not a pest of barley, or (ii) Wintermalt is actually resistant to biotype G. The objective of this study was to determine the pest status of greenbug biotype G in barley by characterizing the response of select barley cultivars and germplasm to greenbug biotype G feeding.

MATERIALS AND METHODS

Eight barley entries ('Post 90', PI 426756, Wintermalt, 'Bancroft', 'Colter', 'Crest', 'Gus', and 'Orca') and four wheat entries [Dickinson Selection 28A (DS28A), Amigo, Largo, and GRS1201] were used in this study. Each barley and wheat entry was tested against biotype G. Reactions of the wheat germplasms DS28A, Amigo, Largo, and GRS1201 to greenbug biotype G are well documented (Porter et al., 1997) and were included in this study as either a resistant or susceptible check to confirm greenbug biotype identity. Post 90 is an improved selection from 'Post' barley that carries the *Rsg1a* resistance gene. This resistance gene provides protection against biotype G (Puterka et al., 1988; Ogecha et al., 1992). PI 426756 carries the *Rsg2b* gene and is also resistant to biotype G (Burd et al., 2003, unpublished data). Post 90 and PI 426756 were included as resistant checks. Wintermalt, Bancroft, Colter, Crest, Gus, and Orca were included in this study because of their divergent reactions to biotype G, as documented during previous preliminary work (D.R. Porter, 2001, unpublished data).

Five seeds of each entry were planted (1.8 cm deep) in hills spaced 5 cm apart within rows and 4.5 cm between rows (replicated six times) in a flat (35 × 51 × 9 cm) containing a mixture of sandy loam soil, sand, and peat (1:1:1 ratio). There was a total of 72 hills per flat (12 entries with 6 replications) in a randomized complete block design. Standard greenbug

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Abbreviations: DS28A, Dickinson Selection 28A.

Table 1. Damage ratings of eight barley and four wheat entries tested against greenbug biotype G.

Entry	Gene designation	Greenbug biotype G Damage rating†
'Post 90'	*Rsg1a*	4.5a‡
PI 426756	*Rsg2b*	5.0ab
'Wintermalt'		5.0ab
'Colter'		4.8ab
'Bancroft'		5.2b
GRS1201	*Gb6*	6.5c
'Crest'		9.0d
'Gus'		9.0d
'Orca'		9.0d
DS28A	*gb1*	9.0d
Amigo	*Gb2*	9.0d
Largo	*Gb3*	9.0d

† 1 = no damage, 9 = dead plant.
‡ Within column, means followed by the same letter are not significantly different (P = 0.05) based on Tukey's Honestly Significant Difference test.

culture and resistance evaluation protocols were used (Starks and Burton, 1977). The test was conducted in a controlled environment growth chamber with a 14-h photoperiod, and temperature ranged from 18 to 22°C night/day. The test was planted on 2 May 2002; seedlings were infested immediately after emergence (6 May 2002); and a composite damage rating (1 = no damage, to 9 = dead plant) was recorded on each group of five seedlings per entry on 28 May 2002, 22 d after infestation, when the susceptible checks rated a 9.0 (i.e., dead plant). Characterization of damage scores was as follows: 1 to 3 (resistant), 4 to 6 (moderately resistant to moderately susceptible), 7 to 9 (susceptible). Data from the test were subjected to ANOVA, and means were compared with Tukey's Honestly Significant Difference test at the 0.05 level.

RESULTS AND DISCUSSION

Mean damage ratings of all entries tested against greenbug biotype G are listed in Table 1. Comparing plant responses of DS28A, Amigo, Largo, GRS1201, and Post 90 confirms the identity of greenbug biotype G. DS28A, Amigo, and Largo are known to be susceptible, while GRS1201 is the only wheat germplasm found to date with resistance to biotype G (Porter et al., 1991). Biotype G is the only biotype that produces this particular response pattern among this set of four wheat germplasms (Porter et al., 1997). In this test, the *Rsg1a* resistance gene in Post 90 provided the best protection against G (rating of 4.5) (Table 1). All of the susceptible checks (DS28A, Amigo, and Largo) were killed (rating of 9.0). The resistant checks, Post 90 (rating of 4.5) and GRS1201 (rating of 6.5), would actually be classified as moderately resistant to moderately susceptible based on the 1 to 9 rating scale. The damage rating of GRS1201 (6.5) in this test can be compared with a rating of 3.3 recorded in a previous study conducted under similar test conditions (Porter et al., 1991). The higher damage rating indicated in this test may have been the result of a longer greenbug infestation period (22 d for this test vs. 19 d for the 1991 test). The present test was allowed to continue an additional 3 d to maximize aphid-feeding pressure for a clear separation of resistant and susceptible entries.

Wintermalt (rating of 5.0) was not significantly different from the resistant checks Post 90 and PI 426756 (Table 1). These results confirm previous reports by Puterka et al. (1988) and Ogecha et al. (1992). In addition to Wintermalt, Colter and Bancroft were also rated resistant (4.8 and 5.2, respectively). In contrast, Crest, Gus, and Orca were highly susceptible and easily killed by biotype G (Table 1).

The results presented in Table 1 were surprising, given the working hypothesis going into this study that barley might not even be a host for greenbug biotype G. The report by Ogecha et al. (1992) comparing biotype G to biotypes E and H showed an inability of G to feed successfully on barley (Post or Wintermalt). Results presented here indicate that barley is indeed a host for biotype G. In this test, biotype G greenbugs uniformly infested the emerging seedlings and quickly colonized the plants. Within the 22-d test, Crest, Gus, and Orca were killed, along with the susceptible wheat checks (DS28A, Amigo, and Largo) (Table 1).

Genetic diversity exists within barley for reaction to attack by greenbug biotype G. On the basis of the damage ratings presented in Table 1, we conclude that Wintermalt, Colter, and Bancroft can be considered new sources of resistance to greenbug biotype G in barley.

Post and PI 426756 have very different reactions from Wintermalt when fed upon by other greenbug biotypes (i.e., Post and PI 426756 are resistant to most biotypes, while Wintermalt is susceptible to most biotypes) (Burd et al., 2003, unpublished data). On the basis of these different biotype reaction profiles, we conclude that the greenbug biotype G resistance gene (or genes) in Wintermalt is (are) different from *Rsg1a* in Post 90 and *Rsg2b* in PI 426756. More work is needed to characterize the genetic control and allelic relationships of these new sources of resistance to biotype G. These new sources of resistance (Wintermalt, Colter, and Bancroft) to greenbug biotype G in barley should prove useful in the development of new greenbug-resistant barley cultivars.

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